Fuel Efficiency in Cars

(1) Aims

At present, fuel efficiency is the most important parameter, judging from the increase crude oil prices and global warming. Discussions about the changes and prospect of fuel efficiency values, the possibility of improvements in efficiency in the future and mechanical limits, and clarifying the image of society if efficiency were improved may provide engineers with social and academic meaning and quantitative targets and contribute to further progress in mechanical engineering.

(2) Social and technical needs

As the growth of social needs for fuel efficiency and solutions to global warming, the fuel efficiencies of cars improved by 22% in the past ten years. They are expected to be reduced by 23.5% by 2015. It is said to be necessary to reduce the GHG (green house gas) exhaust amount to 50 % of the current value by 2050 in order to suppress the temperature rise below 2ºC. However, CO_2 exhaust amount in 2000 in the whole transportation sector has increased up to 120, in 1990 it was 100.

(3) Future directions for determining key mechanisms and parameters

It is necessary to improve the efficiency of the car itself to improve fuel efficiency. Size and weight reduction, hybrid technology, improvement in efficiency of the car body and engine, and other improvements are important to improve car efficiency. To improve efficiency, it is necessary to optimize losses (i.e., aerodynamic resistance, rolling resistance, acceleration resistance, driving force transmission loss and braking loss of the car body, exhaust loss, cooling loss, friction loss, driving of auxiliary parts, and radiation of the engine). The key technologies are the reduction in the Cd value and implementation of platooning for aerodynamic resistance, improvement of tires for the rolling resistance, drastic car weight reduction for the acceleration resistance, multi-stage transmission for driving force transmission loss, and improvement of the regenerative system efficiency and battery energy density/output density for the braking loss (hybrid system development). Cost reduction is necessary to use the above mechanisms widely. In the case of a parallel hybrid system, for example, the batteries and control system share 50 % and 20% of the costs needed for hybrid system achievement, respectively. It is the key in reducing these costs.

Another key is improvement of the efficiency of the external systems (traffic, echo driving and modal shift). Modal shift is important for the ships and railroads and higher-efficiency system construction is required. Besides, remarkable fuel improvements in efficiency of heavy vehicles are also indispensable.

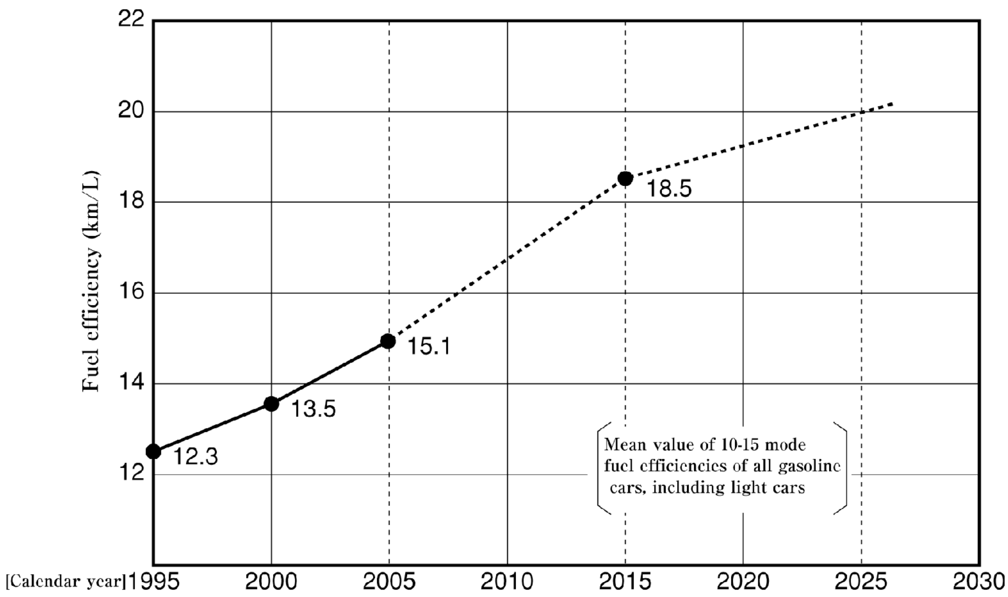
Diversification of fuel (biotechnology and hydrogen for fuel battery cars) is another key to global warming solutions and substitute fuels for petroleum. Bio-ethanol and bio-diesel engines are the key technologies to global warming solutions, though they will not improve fuel efficiency. Improvements in efficiency, higher reliability, remarkable cost reductions, and a supply of hydrogen are problems for fuel battery cars. A great breakthrough is anticipated.

(4) Contributions to society

The exhaust gas reduction technology is the greatest problem in the next ten years. Advanced post-processing technology will enhance propagation of clean diesel engines and play a role of improving the efficiency. The greatest problem in the future is the solution to global warming. In 2050, fuel battery cars and electric cars will share about 40% of the car market (stock base) and hybrid engine cars will share most of the remaining share. Cars will be bipolarized into small-size cars (for local driving) and large-size cars (for long driving). In physical distribution, ships and railroads will increase their shares. In 2100, all cars will be replaced by fuel battery cars (using hydrogen fuel) and electric cars that feature high efficiencies. As a result, the unit of CO_2 emissions from cars will be zero.

Social & Technical Needs

1995～2000	・Exhaust gas reduction
2000～2005	・Exhaust gas reduction
2005～2010	・Exhaust gas reduction ・Exhaust gas and fuel efficiency standards in Japan, U.S.A., and Europe are strengthened remarkably. (2009 problem in the automobile industry) ・Enforcement of Euro 5 (new car exhaust gas regulation in the EU)
2010～2015	・Energy consumption will be reduced to half. ・New tax for CO2 exhaust from airplanes will be introduced in the EU area.
2015～2020	・New fuel consumption standard of the Government will reach the targets. (Passenger car: 16.8 km/L, small bus: 8.9 km/L, small truck: 15.2 km/L)
2020～2025	
2025～2030	・Energy demand will be reduced by 60% in 2050.



Technical Breakthrough

1995～2000	
2000～2005	・Hybrid cars (gasoline and diesel) were put into practical use.
2005～2010	
2010～2015	・DPF exhaust gas purification technology will be combined with urea SCR technology.
2015～2020	
2020～2025	・NOx direct dissolution technology will be put into practical use.
2025～2030	・Gasoline HCCL combustion will be actualized. ・HFCV will be put into practical use.

Changes in Society and Markets

1995～2000	・Automobile NOx Law took effect (in 1992). ・Revised Energy Saving Law (in 1999) ・Diesel Car NO project in Tokyo (from 1999)
2000～2005	・Automobile NOx-PM Law ・Quantity of cars made in Japan: 10.5 million, Quantity of cars sold: 5.87 million
2005～2010	・Next-generation electric cars that suppress running costs down to 1/6 the costs of gasoline cars were released. ・Urea SCR systems for reducing NOx into nitrogen and water will be mainstream for clearing emission control. ・Quantity of bio-ethanol used as car fuel will reach 500,000 kl when converted into crude oil (in 2010).
2010～2015	・1052 million cars will be made in Japan and 5.8 million cars will be sold. ・Electric cars with fuel batteries will be used widely. (50 thousand cars will be registered in Japan.) ・Market of the rechargeable batteries for hybrid cars will reach 300 billion yen. ・Number of hybrid cars used in Japan, U.S.A., and Europe will reach 2.19 million.
2015～2020	・1065 million cars will be made in Japan and 5.43 million cars will be sold. ・Fuel batteries will be widely used as environment-conscious high-efficiency portable power sources (for electric cars and so forth). ・Number of Diesel cars used in the world will reach 29 million orders. ・International hybrid car market will reach 5.37 million.
2020～2025	・Local transportation with very small cars will expand. ・Total traffic will reach the peak, 16% over the current traffic, in 2020 to 2030. ・5 million fuel battery cars will be registered in Japan. ・Infra-network for supplying hydrogen to fuel battery cars will be made.
2025～2030	・Fuel battery hybrid cars and electric cars will share 40% or so in all (by 2050). ・Battery performance will be improved and plug-in type electric cars will be available. ・In 2030 or so, the total traffic will reach the peak, 28% over the current traffic, ・15 million fuel battery cars will be registered in Japan.